Critical species of Odonata in Madagascar

Klaas-Douwe B. Dijkstra [1] **& Viola Clausnitzer** [2]

[1] Gortestraat 11, NL-2311 MS Leiden, The Netherlands. <dijkstra@naturalis.nnm.nl>
[2] Liebenauer Straße 180, D-06110 Halle/Saale, Germany. <violacl@gmx.de>

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Abstract

Madagascar has approximately 175 species of Odonata. Of the Anisoptera ca 60% is endemic and of the Zygoptera almost 95%. The endemic species can roughly be separated into 'new endemics' that are probably recent arrivals from the African mainland and 'old endemics'. The latter group includes many members of the families Megapodagrionidae, Platycnemididae and Corduliidae, which are much more diverse here than on the African continent. Many of these species belong to endemic genera and appear to be restricted to rainforest habitat. The rate of deforestation on Madagascar is alarming, and therefore the majority of 'old endemics' is potentially threatened. One hundred and eleven species, 64% of the fauna, are listed as being of primary concern and their conservation status needs to be assessed immediately. Research on Madagascar's Odonata is urgently needed in all aspects from basic inventories and systematic work to studies on ecology, biogeography and conservation related issues.

Regional definition

The island of Madagascar is situated in the SW Indian Ocean, at the edge of the tropical belt, and is the fourth largest island in the world, with an area of 594,000 km^2. The island is dominated by a central mountainous spine of Precambrian origin with steep eastern and gradual western slopes. The eastern side receives 1,600-4,000 mm annual rainfall, while the western side has a marked dry season and receives 800-1,600 mm per year. Madagascar has numerous freshwater wetlands: lakes – most are smaller than 1 km^2 –, marshes, swamps and streams from the central highlands. Many of these freshwater sites in the west are seasonal. Biogeographically Madagascar has very much its own flora and fauna and boasts a high biodiversity with extremely high levels of endemism, even on the genus and family levels (Goodman & Benstead 2003). The similarity to the African flora and fauna is not very high, and interestingly Gentry (1993) suggests "...that Madagascar is floristically more like the Neotropics than Africa is". Although the data is not suitable for statistical comparisons, on the generic level a certain

Madagascan plot is closer to the Neotropics than to Africa; with 40% shared genera per site for the Neotropics and only 31% shared genera for tropical Africa. This is largely a result of the more stable climate in the Indian Ocean and thus a more stable environment on Madagascar, when compared to Africa, which has undergone mass extinctions due to drastic climatic changes (Maley 1986; Bonnefille et al. 1990).

State of the art

Studies on taxonomy, ecology and biodiversity

The biodiversity research in Madagascar has focused on vertebrates, while invertebrates have been largely neglected. Madagascar is home to about 175 described species of Odonata. Three quarters of the genera and a fifth of the species are shared with continental Africa, the remainder being endemic. Four species are also found in nearby archipelagos. Of the about 80 species of Anisoptera, 60% is endemic. Approximately 95% of the over 90 species of Zygoptera is endemic. The difference between the suborders is explained by the superior dispersal capacity of the Anisoptera. The number of occurring species should be around 200, including both undiscovered colonists from the continent as well as endemics. The fauna shows clear affinities to that of tropical Africa. Nonetheless families well-represented on the mainland, such as Calopterygidae, Chlorocyphidae, Protoneuridae and Macromiidae, are not or very poorly represented. On the other hand, the families Megapodagrionidae, Platycnemididae and Corduliidae are much more diverse here than on the continent.

The species endemic to Madagascar can roughly be separated in two groups. One group – about 20% of the species – is composed of species with close relatives on the African mainland. They are probably derived from recent arrivals of savannah species, which have good dispersal capacity. Examples of such 'new endemics' are *Gynacantha hova*, *Hemistigma affine* and *Zygonyx elisabethae*, close relatives of *G. manderica*, *H. albipunctum* (Rambur, 1842) and *Z. natalensis* (Martin, 1900) respectively. These species probably occur all over the island in open, often anthropogenic, habitats. The other group – the remaining 80% – is composed of species with few or no close relatives on the African mainland. Many of these species belong to (near) endemic genera and are restricted to rainforest habitat. These 'older endemics' include the radiations of genera like *Pseudagrion* and *Platycnemis*, the species being dissimilar to con-generics on the continent.

The study of the Odonata of Madagascar began with Rambur (1842), who described twelve species now known from the island, nine of which are endemic. These included some of the earliest described tropical odonates. All the great odonatologists of the late 19th and early 20th century – Förster, Karsch, Kirby, McLachlan, Martin, Ris, Selys and Sjöstedt – made small contributions between 1872 and 1917; see Bridges (1994) for an overview. The next episode of Malagasy odonatology was to begin with the publication of Schmidt's revision of the Zygoptera in 1944, but the entire edition was destroyed by fire during the Russian

bombardment of Neubrandenburg in 1945. Not until 1951 was his work to appear in an English translation of the proofs produced by Fraser. Dissatisfied with the result, Schmidt republished the work in German in 1966. Fraser himself published numerous papers between 1948 and 1962, including a monograph of the Anisoptera in 1956. Lieftinck (1963, 1965), Pinhey (1964) and Aguesse (1967, 1968) published some taxonomic papers, mainly on Zygoptera. The Odonata of Madagascar have been practically neglected since the 1960s, besides a few species descriptions by Lohmann (1980), Cammaerts (1987), Gauthier (1988) and Legrand (1992, 2001a, 2003) and a few faunistic notes (e.g. Carfì & Terzani 1991).

Identification guides and faunal lists

The only comprehensive treatments of the odonate fauna of Madagascar are the monographs of Fraser (1956) and Schmidt (1951, 1966). Legrand (2001b) produced a checklist of the species, but this was published fairly obscurely. Donnelly & Parr (2003) provide a list and discussion of the fauna in the beautiful overview of Madagascar's biodiversity edited by Goodman & Benstead (2003) but unfortunately this contains so many errors and omissions that it is of little use.

Critical species

For Madagascar only two species have been listed in the 1996 and 2003 Red Lists of threatened species (Moore 1997; IUCN 2003):
as vulnerable [VU]:
Isomma hieroglyphicum; *Libellulosoma minuta*

Eight species were listed as priority species for Madagascar by Moore (1997):
as monotypic genera confined to one country only:
Millotagrion inaequistigma; *Paracnemis alluaudi*; *Isomma hieroglyphicum*; *Malgassogomphus robinsoni*; *Libellulosoma minuta*; *Archaeophlebia martini*; *Viridithemis viridula*
as taxonomically isolated species:
Onychothemis hova

Concerning the species listed by the IUCN (2003) and Moore (1997) it has to be noted that *Isomma* is no longer monotypic (Legrand 2003) and that *Onychothemis hova* is an error, as no such species exists and the genus is confined to tropical Asia. Possibly Moore (1997) was confused by two other zygonyctine species, *Zygonyx hova* or *Olpogastra lachesis*.

Species to be considered

Because of the high diversity and endemism of the Malagasy odonate fauna and the threats posed on wet and forested habitats, a high number of Madagascar species are likely to be of conservation concern. Due to the poor record of recent research, data of all these species are deficient. Study of the distribution, habitat

requirements and systematic identity of these species must clarify their conservation status. Tables 1 and 2 list all the (near) endemic species of Madagascar, which have been sorted (quite arbitrarily) in two categories of concern: Of primary concern (Table 1) are all 'old endemics' of the island, for which only few records appear to be available. This includes all species of endemic genera except *Thermorthemis* which is also known from the Comoros. Of secondary concern (Table 2) are species that have been removed from the first list because they appear to be more widespread, e.g. more published records or also known from nearby archipelagos, or are taxonomically suspicious, e.g. possibly synonymous with continental species. This includes most 'new endemics'. One hundred and eleven species – 64% of the fauna – are listed of primary concern, and their conservation status should be assessed immediately.

Table 1. Odonata endemic to Madagascar of primary conservation concern. G: belongs to endemic genus; R: genus with large and distinctive radiation in Madagascar.

Family/species	**Genus**
Lestidae	
Lestes auripennis Fraser, 1955	
pruinescens Martin, 1910	
silvaticus (Schmidt, 1951)	
Megapodagrionidae	
Nesolestes albicauda Fraser, 1952	R
albicolor Fraser, 1955	R
alboterminatus Selys, 1891	R
angydna Schmidt, 1951	R
drocera Fraser, 1951	R
elisabethae Lieftinck, 1965	R
forficuloides Fraser, 1955	R
mariae Aguesse, 1968	R
martini Schmidt, 1951	R
pulverulans Lieftinck, 1965	R
radama Lieftinck, 1965	R
ranavalona Schmidt, 1951	R
robustus Aguesse, 1968	R
rubristigma Martin, 1902	R
tuberculicollis Schmidt, 1951	R
Protolestes fickei Förster, 1899	G
furcatus Aguesse, 1967	G
kerckhoffae Schmidt, 1949	G
leonorae Schmidt, 1949	G
milloti Fraser, 1949	G
proselytus Lieftinck, 1965	G
rufescens Aguesse, 1967	G
simonei Aguesse, 1967	G

Family/species	Genus
Megapodagrionidae (continued)	
Tatocnemis crenulatipennis Fraser, 1952	G
denticularis Aguesse, 1968	G
emarginatipennis Fraser, 1960	G
malgassica Kirby, 1889	G
mellisi Schmidt, 1951	G
micromalgassica Aguesse, 1968	G
olsufieffi Schmidt, 1951	G
robinsoni Schmidt, 1951	G
sinuatipennis Selys, 1891	G
virginiae Legrand, 1992	G
Coenagrionidae	
Africallagma rubristigma (Schmidt, 1951)	
Agriocnemis merina Lieftinck, 1965	
Ceriagrion madagazureum Fraser, 1949	
nigrolineatum Schmidt, 1951	
oblongulum Schmidt, 1951	
Ischnura filosa Schmidt, 1951	
Millotagrion inaequistigma Fraser, 1953	G
Pseudagrion alcicorne Förster, 1906	R
ambatoroae Aguesse, 1968	R
ampolomitae Aguesse, 1968	R
apicale Schmidt, 1951	R
approximatum Schmidt, 1951	R
cheliferum Fraser, 1949	R
chloroceps Fraser, 1955	R
deconcertans Aguesse, 1968	R
digitatum Schmidt, 1951	R
dispar Schmidt, 1951	R
divaricatum Schmidt, 1951	R
giganteum Schmidt, 1951	R
hamulus Schmidt, 1951	R
igniceps Fraser, 1953	R
lucidum Schmidt, 1951	R
macrolucidum Aguesse, 1968	R
mellisi Schmidt, 1951	R
merina Schmidt, 1951	R
nigripes Schmidt, 1951	R
olsufieffi Schmidt, 1951	R
pterauratum Aguesse, 1968	R
renaudi Fraser, 1953	R
seyrigi Schmidt, 1951	R
simile Schmidt, 1951	R
stuckenbergi Pinhey, 1964	R
tinctipenne Fraser, 1951	R
trigonale Schmidt, 1951	R
ungulatum Fraser, 1951	R
vakoanae Aguesse, 1968	R

Family/species	Genus
Platycnemididae	
Metacnemis secundaris Aguesse, 1968	
Paracnemis alluaudi Martin, 1902	G
Platycnemis alatipes (MacLachlan, 1872)	R
aurantipes Lieftinck, 1965	R
hova Martin, 1908	R
longiventris Schmidt, 1951	R
protostictoides Fraser, 1953	R
pseudalatipes Schmidt, 1951	R
sanguinipes Schmidt, 1951	R
Aeshnidae	
Anax mandrakae Gauthier, 1988	
Gynacantha malgassica Fraser, 1962	
radama Fraser, 1949	
Gomphidae	
Isomma elouardi Legrand, 2003	G
hieroglyphicum Selys, 1892	G
Malgassogomphus robinsoni Cammaerts, 1987	G
Onychogomphus aequistylus Selys, 1892	
vadoni Paulian, 1960	
Paragomphus fritillarius (Selys, 1892)	
obliteratus (Selys, 1892)	
z-viridum Fraser, 1955	
Corduliidae	
Libellulosoma minuta Martin, 1907	G
Nesocordulia flavicauda MacLachlan, 1882	G
malgassica Fraser, 1956	G
mascarenica Fraser, 1948	G
rubricauda Martin, 1900	G
spinicauda Martin, 1902	G
Libellulidae	
Archaeophlebia martini (Selys, 1896)	G
Calophlebia interposita Ris, 1909	G
karschi Selys, 1896	G
Crocothemis striata Lohmann, 1981	
Lokia modesta Ris, 1909	
Malgassophlebia mayanga (Ris, 1909)	
mediodentata Legrand, 2001	
Neodythemis arnoulti Fraser, 1955	R
pauliani Fraser, 1952	R
trinervulata (Martin, 1902)	R
Trithemis persephone Ris, 1912	
Viridithemis viridula Fraser, 1960	G
Zygonyx viridescens (Martin, 1900)	

Critical sites and threats

The natural habitats of Madagascar have suffered seriously from deforestation, erosion and pollution in past centuries. Wetlands are "now heavily polluted with fertilisers and insecticides and clogged with sediments" (Fishpool & Evans 2001: 492), and the natural vegetation has been replaced largely by non-native *Eichhornia* and *Salvinia*. Madagascar has lost most of its forest cover, while deforestation is continuing at an alarming rate today (Green & Sussman 1990; Sayer et al. 1992; Du Puy & Moat 1996). Denuded soils are easily eroded, dissipating into the sea. Rainwater that should be absorbed and gradually discharged into the watershed is no longer retained. This leads to the loss of permanent sources of water. The paradox of Madagascar's crisis is disconcerting: a growing population puts escalating pressure on the environment and simultaneously creates an increasing demand for dependable sources of water.

Conservation priorities and recommendations

The protection of Madagascar's forests is crucial for the survival of its unique odonate fauna. Destruction has led to fragmentation of the remaining remnant forests, and these isolated remnants are particularly vulnerable to further disturbance. Linking up fragments by creating forest corridors can form larger networks that can support greater biological wealth. For an overview on general conservation infrastructure see Fishpool & Evans (2001: 498-499).

Table 2. Odonata endemic or mainly confined to Madagascar of secondary concern. For abbreviations see Table 1. The reason for assigning only secondary concern is given.

Family/species	Genus	Remark
Lestidae		
Lestes simulator (MacLachlan, 1895)		Probably widespread
Coenagrionidae		
Azuragrion kauderni (Sjöstedt, 1917)		Widespread, also occurs on Comoros
Ceriagrion auritum Fraser, 1951		Probably widespread
Pseudagrion malgassicum Schmidt, 1951	R	Probably widespread
punctum (Rambur, 1842)	R	Widespread, also occurs on Mascarenes
Teinobasis berlandi Schmidt, 1951		Probably synonym of *T. alluaudi* of mainland Africa and Seychelles
Platycnemididae		
Platycnemis malgassica Schmidt, 1951	R	Probably widespread
Aeshnidae		
Anax tumorifer MacLachlan, 1885		Probably widespread
Gynacantha hova Fraser, 1956		Possibly synonym of widespread mainland *G. manderica* Grünberg, 1902

Family/species	Genus	Remark
Gomphidae		
Onychogomphus flavifrons Selys, 1894		Possibly synonym of *O. aequistylus* (which is of first concern)
Paragomphus madegassus (Karsch, 1890)		Possibly synonym of widespread mainland *P. genei* (Selys, 1841)
Corduliidae		
Hemicordulia similis (Rambur, 1842)		Probably widespread, also reported from Seychelles
Phyllomacromia trifasciata (Rambur, 1842)		Probably widespread
Libellulidae		
Diplacodes exilis Ris, 1911		Probably widespread
Hemistigma affine (Rambur, 1842)		Probably widespread
Neodythemis hildebrandti Karsch, 1889	R	Probably widespread
Olpogastra lachesis Ris, 1912		Probably widespread
Orthetrum azureum (Rambur, 1842)		Widespread, ssp. *lugubre* on Comoros
lemur Ris, 1909		Probably widespread
Palpopleura vestita Rambur, 1842		Probably widespread
Rhyothemis cognata (Rambur, 1842)		Probably widespread
Thermorthemis madagascariensis (Rambur, 1842)	G	Widespread, close relative *T. comorensis* Fraser 1958 on Comoros
Trithemis selika (Selys, 1869)		Widespread, ssp. *maia* Ris, 1915 on Comoros
Zygonyx elisabethae Lieftinck, 1963		Probably widespread
hova (Rambur, 1842)		Possibly synonym of widespread mainland *Z. torridus* (Kirby, 1889)
ranavalonae Fraser, 1949		This or closely related species occurs on Comoros

Research priorities

Research on Madagascar's Odonata is urgently needed in all aspects from basic inventories and systematic work to studies on ecology, biogeography and conservation related issues. The first priority – which will facilitate all other scientific progress – is the production of a critical checklist and reliable identification literature. Since extensive stretches of forest have been cleared over the last decades an inventory of the odonate fauna of Madagascar and a comparison to the sparse earlier records is urgently needed. On the other hand, progress has been made in the conservation of forest and protected areas have been created. It is important to know how the island's unique fauna has fared since and whether it has profited from these measures. Tools are needed to measure degrees of landscape disturbance, as well as conservation success (see previous paragraphs). Odonata can be such a tool.

Current activities

On the Odonata side, not much work has been done in the last half century. A small survey has been undertaken recently in the dry Ankarafantsika Forest (García & Dijkstra 2004), whilst a PhD project on the biogeography and habitat affinity of the odonate fauna of SE Madagascar (region of Tolagnaro) has been started by K. Schuette (Zoologisches Institut, Universität Hamburg). The work by Butler (2003a, 2003b), Donnelly & Parr (2003) and Legrand (2001a, 2001b, 2003) is also based on some recent fieldwork.

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